RF Cavity Vacuum Interlocks

Controls and Interlocks
System Requirements Specification

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System Description

The RF Cavity Vacuum Interlock System is responsible for the control of two pneumatically operated vacuum gate valves connected to the RF cavities in sectors 36 through 40. It will consist of a 19-inch rack mount chassis containing a PLC system, front-panel controls and indicators, and rear-panel connections for field devices (inputs and outputs). The system will be controlled via the front panel, or by remote connection via EPICS operator screens.

The two valves that this system will control are 1) The Roughing Valve, which is responsible for isolating the roughing pump and line from the Turbo pump and 2) The Turbo Valve, which is responsible for isolating the Turbo from the RF Cavities (figure A1).

In general, this system is a highly modified Vacuum Valve Controller. It will be responsible for protecting the RF cavities (and furthermore, the storage-ring) from an inadvertent increase in pressure by isolating sections of marginal vacuum by closing one or two valves. A variety of field device dry-contact setpoints will be used by the system to assess the status of the vacuum. In general, any device whose setpoint contact opens will cause the system to close all valves[1]. Furthermore, the system will not allow a valve to open until the vacuum on either side is known to be adequate (except for the override mode, described below).

For maintenance purposes, the system can be put into "override" mode that will allow the opening of the either valve with poor vacuum. This is necessary for the situation in which the cavities need to be pumped down from a higher than normal pressure. This mode will only be accessible locally from the front panel.

The system will always be in one of three states – operational, fault or override.

The operational state is the normal state of the system. While in this state, all setpoint contacts are being monitored, and any open contact will cause the state to transition to the fault state.

While in the fault state, both valves are commanded to close, the sequence of events is stored within the PLC processor, and the initial cause of the fault is indicated on the front panel by flashing the pertinent LED.

The override state is entered by an operator pressing the override button while the system is faulted. This allows the either valve to be opened at will[2], even if the vacuum is not adequate to keep the system in the operational state. At this point, when all setpoints are again made-up, the system will transition to the operational state.

[1] The two Ion Pump controller setpoints are used in a logical 'OR' configuration – if either one of them indicates an adequate vacuum, the system will <u>not</u> fault.

[2] See the "Operational Details" section for a detailed description of the override mode.

System Details

Discrete Inputs

Name	Type	Description
RP_SP	Contact	Roughing pump setpoint, made when speed is adequate
TP_SP	Contact	Turbo pump setpoint, made when speed is adequate
CG_SP	Contact	Convectron Gauge Setpoint, made when vacuum is adequate
IP1_SP2	Contact	Ion Pump #1 Setpoint 2, made when vacuum is adequate
IP3_SP2	Contact	Ion Pump #3 Setpoint 2, made when vacuum is adequate
RV_OP_LS	Contact	Roughing valve OPEN limit switch, made when valve is open
RV_CL_LS	Contact	Roughing valve CLOSE limit switch, made when valve is closed
TV_OP_LS	Contact	Turbo valve OPEN limit switch, made when valve is open
TV_CL_LS	Contact	Turbo valve CLOSE limit switch, made when valve is closed
RV_OP_PB	Pushbutton	Open command for Roughing valve
RV_CL_PB	Pushbutton	Close command for Roughing valve
TV_OP_PB	Pushbutton	Open command for Turbo valve
TV_CL_PB	Pushbutton	Close command for Turbo valve
OVR_PB	Pushbutton	Override command
RST_PB	Pushbutton	Reset command
LAMP_PB	Pushbutton	Lamp test command

Total inputs: 16

Note: IP1_SP2 and IP3_SP3 must both indicate bad vacuum for a fault to occur. This can be denoted as a "soft input" IP_SP consisting of the Boolean expression (IP1_SP2 OR IP3_SP2).

Discrete Outputs

Name	Type	Description
RV_OP_CMD	24V Source	Roughing valve open signal
TV_OP_CMD	24V Source	Turbo valve open signal
RV_OP_LED	24V Source	Roughing valve open indicator
RV_CL_LED	24V Source	Roughing valve closed indicator
TV_OP_LED	24V Source	Turbo valve open indicator
TV_CL_LED	24V Source	Turbo valve closed indicator
RP_STAT_LED	24V Source	Roughing pump status indicator
TP_STAT_LED	24V Source	Turbo pump status indicator
CG_STAT_LED	24V Source	Convectron guage status indicator
IP1_STAT_LED	24V Source	Ion Pump #1, setpoint 1 status indicator
IP3_STAT_LED	24V Source	Ion Pump #3, setpoint 1 status indicator
OVR_STAT_LED	24V Source	Override active indicator
FLT_STAT_LED	24V Source	Fault status indicator

Total Outputs: 13

Communication interfaces

Description	Type	Specifics	Notes
Ion Pump #1 Readbacks	Serial BUG	L1 N1 P0	In place
Ion Pump #3 Readbacks	Serial BUG	L1 N2 P0	In place
Convectron Gauge Readbacks	Serial BUG	L1 N? P?	In place - different nbr per sector
Interlock box readback/control	DirectNet BUG	L1 N# P#	New

Operational details

The system will be designed within a 19” rack mounted chassis. Mounted within the chassis will be the PLC subsystem (consisting of a backplane, processor and I/O modules), a 24Vdc power supply for valve actuation, a 24Vdc power supply for field I/O and front panel display, and wiring blocks. The rear panel will contain connectors to interface to the various field devices. The front panel will have indicators for all device setpoint statuses, valve positions and the interlock system status. Control of valves and system reset/override will be done through front-panel pushbuttons (see figure A2).

If all pump and gauge setpoints are satisfied, the system is said to be in “<u>operational mode</u>”, if any setpoint is not satisfied and the override button has not been pressed, the system is said to be in “<u>fault mode</u>”. If any setpoint is not satisfied and the override button has been pressed, the system is said to be in “<u>override mode</u>”. It is not possible to enter override mode from operational mode. Override mode will remain in effect until either 1) the system enters operation mode, or 2) the override button is pressed again, forcing the system into fault mode. Transitioning from fault mode to operational mode requires all setpoints to be satisfied, and the Reset button be pressed. Transitioning from override mode to operational mode requires all setpoints be satisfied. A state-transition diagram for the system in general is shown in figure B1.

The operation of the valves is dependant on the vacuum condition on either side of the valve, and the state of the system. Either valve may be opened when the system is in operational mode. During Override mode, the roughing valve may be opened at will. The Turbo valve may be opened during override mode, only when both Ion Pump show an adequate vacuum. Again, the new Vacuum Valve Controller will be used as a model for the control of the valves. Each valve will be in one of six states: <u>Closed</u>, <u>Opening</u>, <u>Opened</u>, <u>Closing</u>, <u>Close Fault</u>, or <u>Open Fault</u>. State transition diagrams for both valves are shown in figures B2 and B3.

Valve malfunctions may also cause system state transitions as follows:

- A valve previously in a steady-state condition and currently indicating motion will cause the system to fault.
- A valve whose commanded move does not complete in a finite amount of time will cause the system to fault.

All faults will be latched to avoid system transition oscillations. Each setpoint input will, in effect, have it’s own task that will be in one of three states: <u>Active</u>, <u>Inactive</u> or <u>Fault</u> (fig B4).

In summary:

- If the system is in <u>operational mode</u>, either valve may be opened or closed at will.
- If the system is in <u>override mode</u>, the roughing valve may be opened or closed at will. The turbo valve operation will be determined by the pertinent setpoints (**IP1_SP1** and **IP3_SP1**).
- If the system is in <u>fault mode</u>, both valves are commanded to close, and cannot be opened until the system enters a different state.

The device will power up in fault mode.

Installation

The system chassis source of power will be the standard (non-emergency) circuit(s). In the event of a site-wide loss of power, both valves will close.

Concerns

It is very important that all respective device setpoints be adjusted to values that will allow the system to act quick enough to avoid a catastrophe, while not generating numerous nuisance trips. Qualified people outside of the controls group must determine these values.

It is also necessary to determine the timeout values for valve actuation.

EPICS interface

The control system will be able to monitor each point of I/O via MEDM screens. Existing analog values will be included on the new screens when necessary.

All front panel indicators and will be available to the operators.

Remote control will be limited to valve motion and system reset (override will not be available).

Finally, as an aid to diagnostics, a fault log will be provided which will time-stamp the first event that causes the chassis to fault.

Appendix A: Drawings

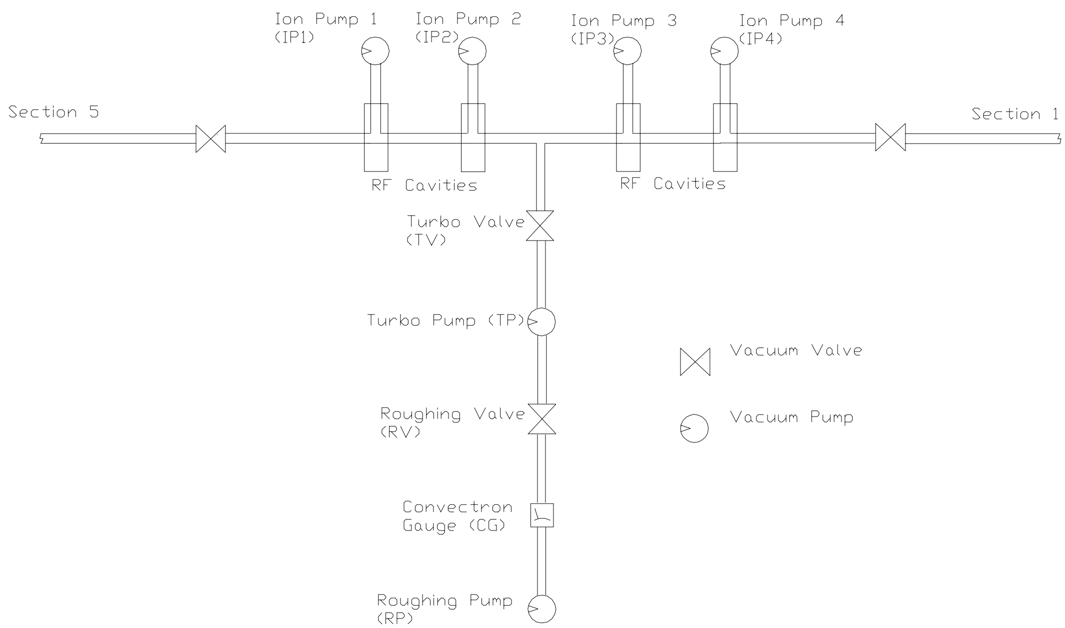

Figure A1: General Vacuum Schematic

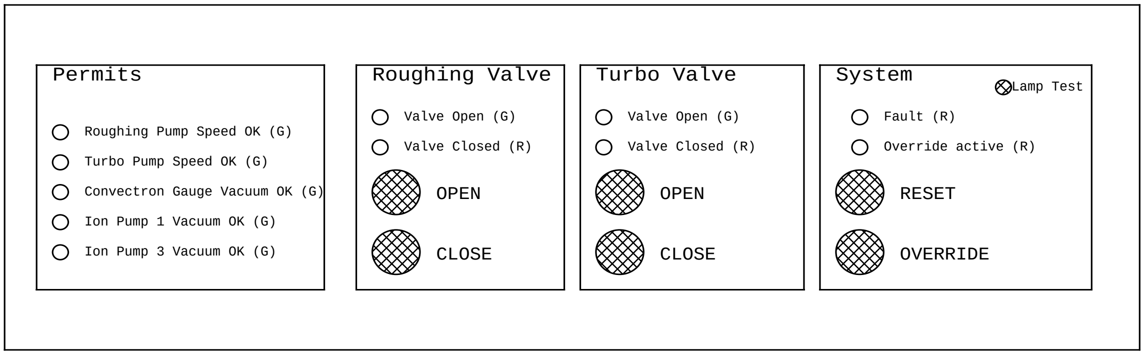

Figure A2: Front Panel Layout

Appendix B: State Transition Diagrams

Notes: In general inputs are denoted in normal black type.
Boolean expressions are denoted in *UPPER-CASE ITALIC RED* type.
Outputs are denoted as [Blue type within Brackets].
Forced state transitions are denoted as { Orange type within braces }.

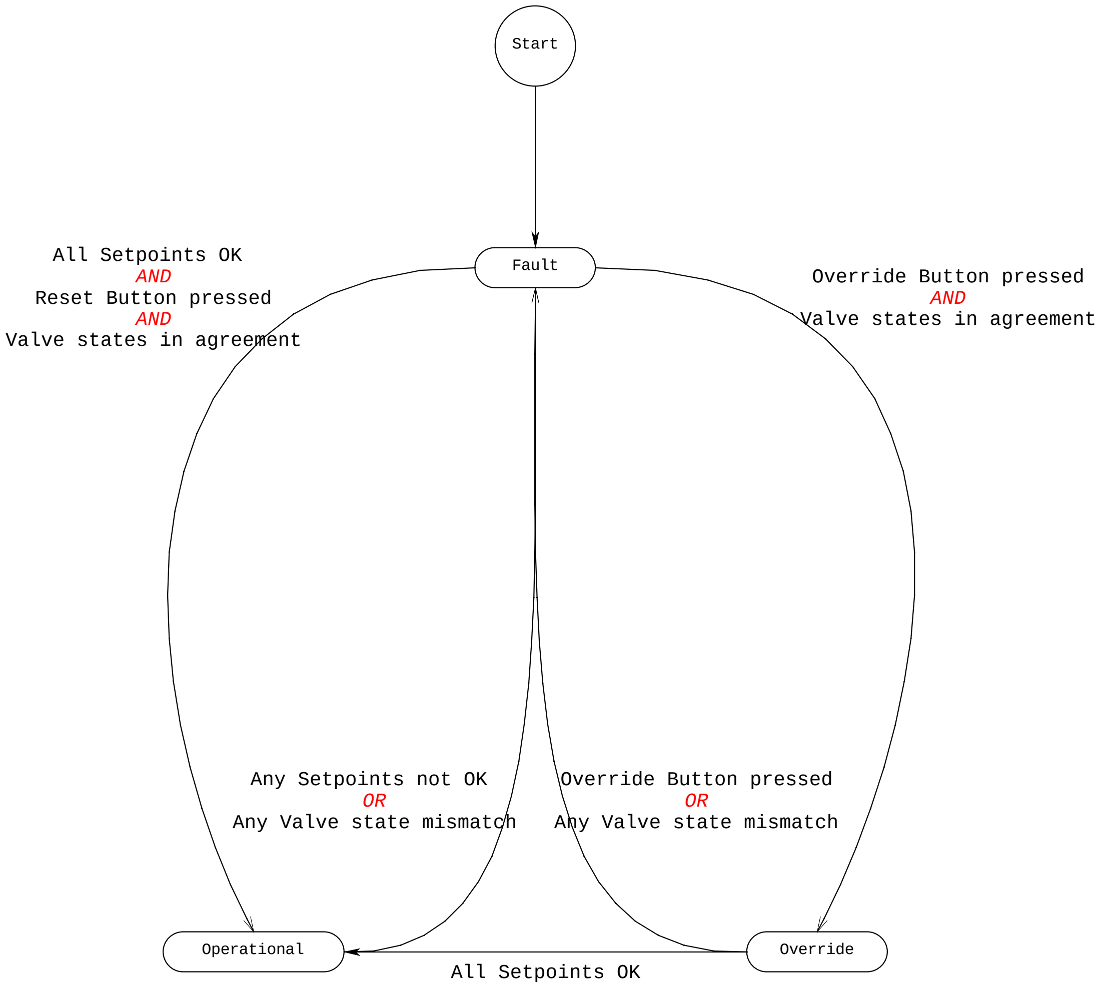

Figure B1: System state-transition diagram

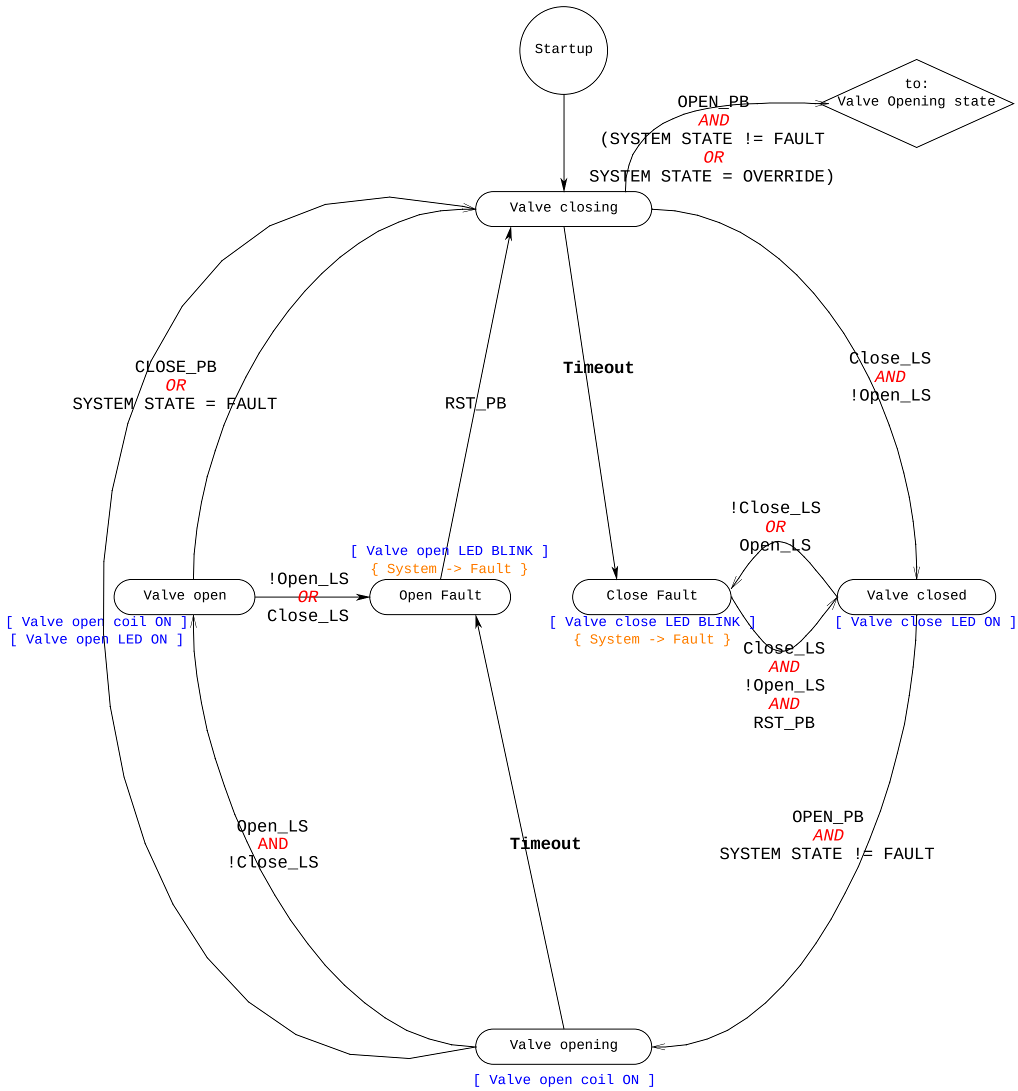

Figure B2: Roughing Valve state-transition diagram

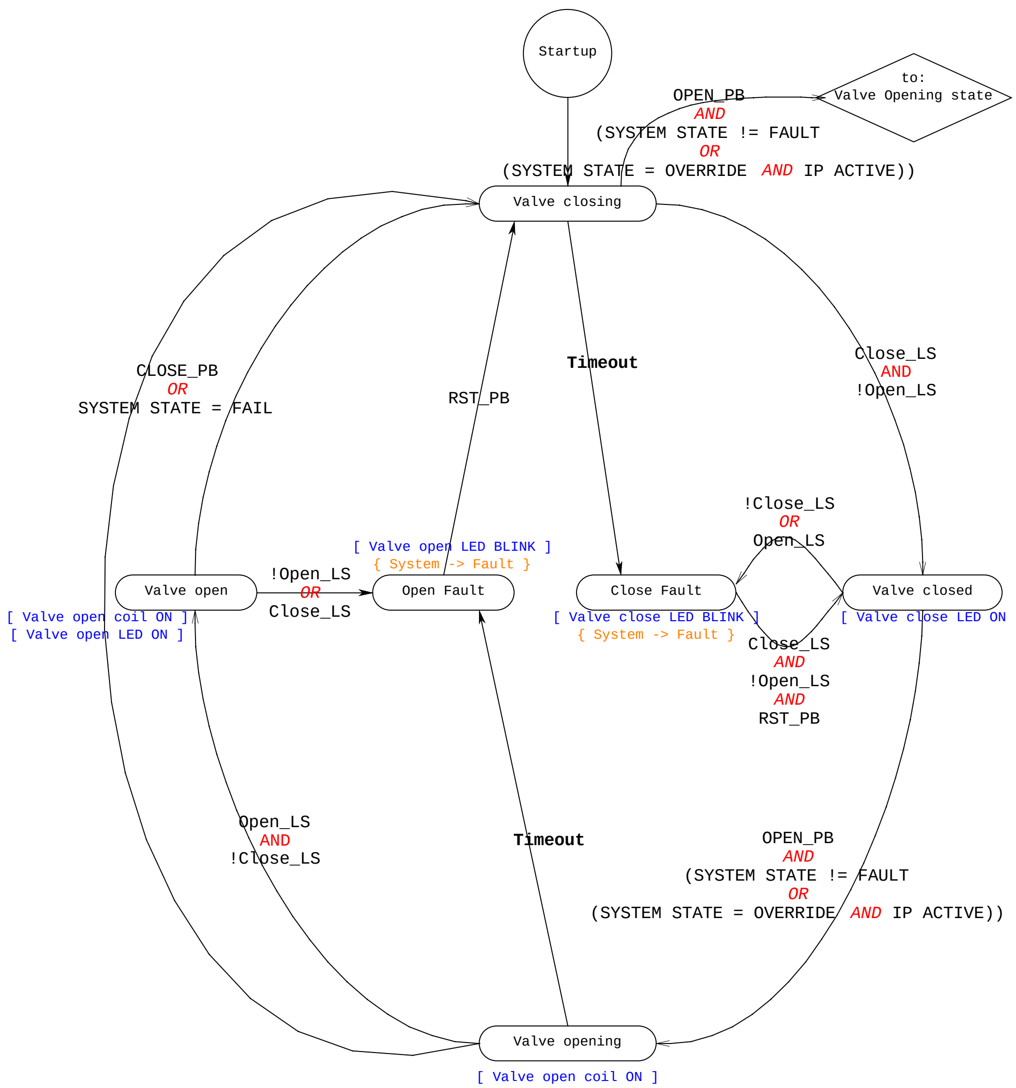

Figure B3: Turbo Valve state-transition diagram

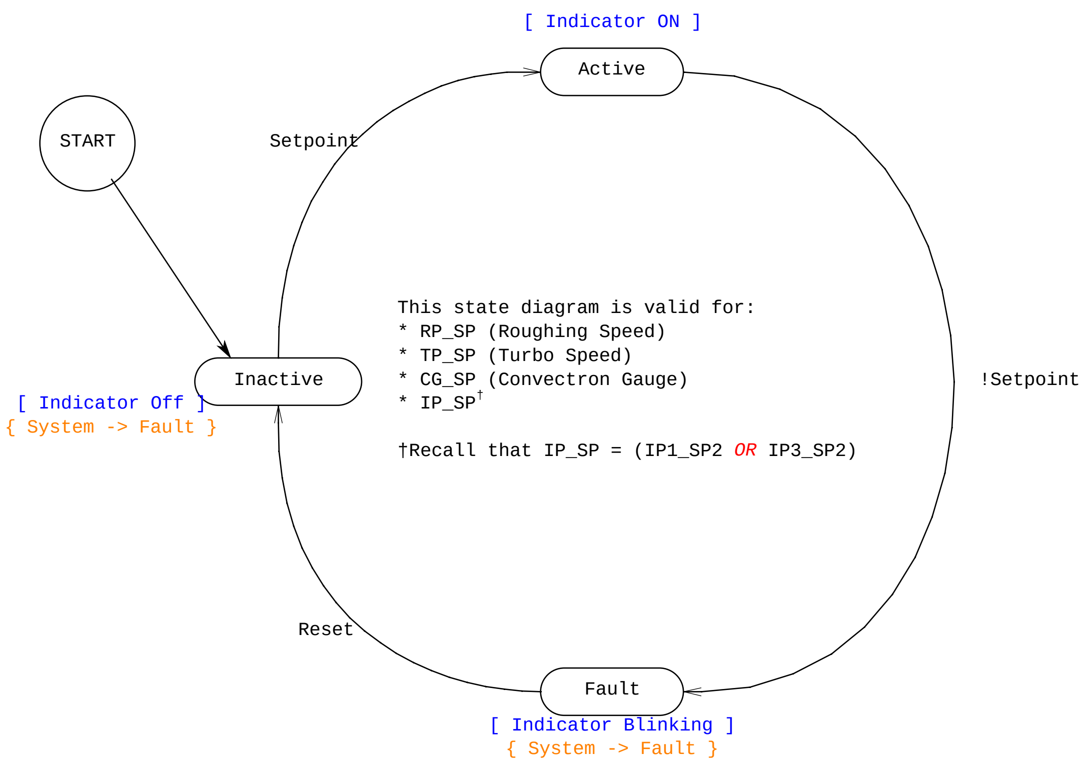

Figure B4: Permit state-transition diagram